Claims

1. A drive shaft comprising:

an elongated composite material portion having opposing ends; and

at least one end adapter disposed at one end of the composite material portion, the end adapter being captured into the composite material portion during the process of manufacturing.

2. The drive shaft according to claim 1, wherein the end adapter is metallic.

3. The drive shaft according to claim 1, wherein the end adapter is non-metallic.

4. The drive shaft according to claim 1, wherein the composite material portion is formed from a braided fiber and resin transfer molded composite.

5. The drive shaft according to claim 4, wherein the braided fiber is a two-dimensional braided fiber.

6. The drive shaft according to claim 4, wherein braided fiber is a three-dimensional braided fiber.

7. The drive shaft according to claim 1, wherein the composite material portion is formed from a filament wound composite.

8. The drive shaft according to claim 1, wherein the end adapter comprises:

a component interface portion adapted for coupling to a driving or driven component; and

an adapter-tube interface portion;

wherein the adapter-tube interface portion is adapted to be captured into the composite material portion during the process of manufacturing.

9. The drive shaft according to claim 8, wherein the end adapter further comprises:

a means for transferring torque from the end adapter to the composite material portion and vice versa.

10. The drive shaft according to claim 8, wherein the end adapter further comprises:

a layer of adhesive disposed between the end adapter and the composite material portion.

11. The drive shaft according to claim 8, wherein the end adapter further comprises:

a neck portion disposed between the component interface portion and the adapter-tube interface portion, the neck portion having a reduced cross-sectional area.

12. The drive shaft according to claim 8, wherein the end adapter further comprises:

at least one recessed circumferential groove around the adapter-tube interface portion.

13. The drive shaft according to claim 8, wherein the end adapter further comprises:

at least one outwardly protruding lug disposed at the adapter-tube interface portion.

14. The drive shaft according to claim 13, wherein each lug comprises:

a circumferentially exterior lug face;

a lug flank on each side of the lug face for transmitting torque from the end adapter to the composite material portion and vice versa;

a lug base between the lug flanks of adjacent lugs; and

a tapered lug end on each longitudinal end of the lug for supporting axial tensile loads, axial compressive loads, and bending moments.

15. The drive shaft according to claim 14, wherein the lug flanks of adjacent lugs are radially aligned.

16. The drive shaft according to claim 14, wherein the lug flanks are longitudinally angled from zero to any degree.

17. The drive shaft according to claim 14, wherein the lug flanks include a longitudinal crown.

18. The drive shaft according to claim 13, wherein the lug is solid.

19. The drive shaft according to claim 13, wherein the lug is hollowed out to reduce weight.

20. A method of manufacturing a drive shaft comprising the steps of:
providing a mandrel;
providing at least one end adapter;
placing the end adapter over the mandrel;
applying polymer or plastic fibers over the mandrel and end adapter to form a preform;
providing a mold configured to fit over the preform;
enclosing the preform with the mold;
heating the assembly of mold and preform;
vacuuming the mold;
injecting resin into the mold;
curing the resin to form the drive shaft;
removing the mold; and
removing the mandrel.

21. The method according to claim 20, further comprising the step of:
placing a layer of adhesive on the adapter-tube interface portion of the end adapter before the step of applying the polymer or plastic fibers over the mandrel and end adapter to form a preform.

22. A method of manufacturing a drive shaft comprising the steps of:
providing a mandrel;
providing at least one end adapter;
placing the end adapter over the mandrel;

applying pre-impregnated fibers by filament winding or filament placement over the mandrel and end adapter;

providing vacuum bags;

enclosing the filament wound drive shaft with the vacuum bags;

vacuuming the bags;

curing the resin;

removing the vacuum bags; and

removing the mandrel.